CLAIMS

What is claimed is:

1. A refrigerator having a compressor for compressing a coolant, a radiator for radiating heat from the coolant, a flow control valve for regulating the flow volume of the coolant, and an evaporator for evaporating the coolant, characterized in that the refrigerator includes:

a coolant cooling means for cooling the coolant; and

a heat-exchange-amount control means for controlling the amount of heat exchanged in the coolant cooling means; wherein

the coolant is circulated through the compressor, the radiator, the coolant cooling means, the flow control valve, and the evaporator, in that sequence.

2. A refrigerator as recited in claim 1, utilizing a nonflammable coolant whose global warming potential is lower than that of chlorofluorocarbon, wherein the coolant cooling means includes:

a second compressor for compressing a second coolant whose energy consumption efficiency is higher than that of the coolant;

a condenser for radiating heat from the second coolant;

a second flow control valve for regulating the flow volume of the second coolant; and

a second evaporator for evaporating, by means of heat from the coolant, the second coolant; wherein

the second coolant is circulated through the second compressor, the condenser, the second flow control valve, and the second evaporator, in that sequence.

3. A refrigerator as recited in claim 1, the compressor having an intermediary-pressure inlet for drawing in the coolant during compressing, the refrigerator further comprising:

a gas-liquid separator for separating into gas and liquid the coolant as

outputted from the flow control valve;

a bypass pipe for introducing into the intermediary-pressure inlet part or all of the coolant gas separated by the gas-liquid separator; and

a third flow control valve for regulating the flow volume of the coolant as outputted from the gas-liquid separator and inputted into the evaporator.

4. A refrigerator as recited in claim 1, further comprising:

a third compressor for compressing the coolant as compressed by the compressor;

a gas-liquid separator for separating into gas and liquid the coolant as outputted from the flow control valve;

a bypass pipe for introducing into the third compressor part or all of the coolant gas separated by the gas-liquid separator; and

a third flow control valve for regulating the flow volume of the coolant as outputted from the gas-liquid separator and inputted into the evaporator; wherein

the coolant as outputted from the third compressor is inputted into the radiator.

5. A refrigerator as recited in claim 1, further comprising:

a third radiator for radiating heat from the coolant as outputted from the compressor; and

a third compressor for compressing the coolant in a state in which heat of the coolant has been radiated away by the third radiator; wherein

the coolant is flowed through the third radiator, the third compressor, and the radiator, in that sequence.

6. A refrigerator as recited in claim 2, further comprising:

a third compressor for compressing the coolant as compressed by the compressor; and

a third heat exchanger for exchanging heat between the coolant and the

second coolant; wherein

the coolant as outputted from the compressor is flowed through the third heat exchanger, the third compressor, and the radiator, in that sequence, and

the second coolant as outputted from the second evaporator is flowed through the third heat exchanger, and the second compressor, in that sequence.

7. A refrigerator as recited in claim 2, further comprising:

a third compressor for compressing the coolant as compressed by the compressor;

a third heat exchanger for exchanging heat between the coolant and the second coolant; and

a forth flow control valve for regulating the flow volume of the second coolant flowing in the third heat exchanger; wherein

the coolant as outputted from the compressor is flowed through the third heat exchanger, the third compressor, and the radiator, in that sequence, and

part of the second coolant as outputted from the condenser is flowed through the forth flow control valve, the third heat exchanger, and the second compressor, in that sequence.

8. A refrigerator as recited in claim 1, wherein the heat-exchange-amount control means includes:

a drying-ratio estimation means for estimating, by a measured value using a predetermined sensor, a drying ratio that is a ratio between a drying rate of the coolant at the exit of the flow control valve and a drying rate when the coolant at the exit of the radiator is decompressed to its evaporation temperature;

a drying-ratio control-range determination means for determining a control range of the drying ratio, so that a COP value is obtained, in which the difference between the value and the maximum value obtained when the drying ratio is varied under predetermined operational conditions is within a predetermined range; and

a control means for controlling the amount of heat exchanged in the coolant

cooling means, so that the drying ratio estimated by the drying-ratio estimation means is within the control range.

9. A refrigerator as recited in claim 2, wherein the heat-exchange-amount control means includes:

a drying-ratio estimation means for estimating, by a measured value using a predetermined sensor, a drying ratio that is a ratio between a drying rate of the coolant at the exit of the flow control valve and a drying rate when the coolant at the exit of the radiator is decompressed to its evaporation temperature;

a drying-ratio control-range determination means for determining a control range of the drying ratio, so that a COP value is obtained, in which the difference between the value and the maximum value obtained when the drying ratio is varied under predetermined operational conditions is within a predetermined range; and

a control means for controlling the flow volume of the second coolant flowing in the coolant cooling means, so that the drying ratio estimated by the drying-ratio estimation means is within the control range.

10. A refrigerator as recited in either claim 8 or claim 9, wherein the predetermined sensor includes:

at least one of a first pressure-measuring means for measuring pressure of the coolant between the exit of the flow control valve and the entrance of the evaporator, and a first temperature-measuring means for measuring temperature of the coolant at the exit of the flow control valve;

a second pressure-measuring means for measuring pressure of the coolant between the compressor and the flow control valve;

a second temperature-measuring means for measuring temperature of the coolant at the entrance of the flow control valve; and

a third temperature-measuring means for measuring temperature of the coolant at the exit of the radiator.

11. A refrigerator as recited in either claim 8 or claim 9, wherein the predetermined sensor includes:

a first temperature-measuring means for measuring temperature of the coolant at the exit of the flow control valve;

a second temperature-measuring means for measuring temperature of the coolant at the entrance of the flow control valve;

a third temperature-measuring means for measuring temperature of the coolant at the exit of the radiator;

a forth temperature-measuring means for measuring temperature of the coolant at the entrance of the radiator; and

a fifth temperature-measuring means for measuring temperature of the coolant at the entrance of the compressor.

12. A refrigerator as recited in claim 1, further comprising:

a second temperature-measuring means for measuring flow-control-valve entrance temperature as coolant temperature at the entrance of the flow control valve;

wherein the heat-exchange-amount control means includes:

a flow-control-valve-entrance-temperature control-range determination means for determining a control range of the flow-control-valve entrance temperature, so that a COP value is obtained, in which the difference between the value and the maximum value obtained when the flow-control-valve entrance temperature is varied under predetermined operational conditions is within a predetermined range; and

a control means for controlling the amount of heat exchanged in the coolant cooling means, so that the coolant temperature measured by the second temperature-measuring means is within the control range.

13. A refrigerator as recited in claim 2, further comprising:

a second temperature-measuring means for measuring flow-control-valve entrance temperature as coolant temperature at the entrance of the flow control valve;

wherein the heat-exchange-amount control means includes:

a flow-control-valve-entrance-temperature control-range determination means for determining a control range of the flow-control-valve entrance temperature, so that a COP value is obtained, in which the difference between the value and the maximum value obtained when the flow-control-valve entrance temperature is varied under predetermined operational conditions is within a predetermined range; and

a control means for controlling the flow volume of the second coolant flowing in the coolant cooling means, so that the coolant temperature measured by the second temperature-measuring means is within the control range.

14. A refrigerator as recited in claim 1, further comprising:

a third temperature-measuring means for measuring coolant temperature at the exit of the radiator; wherein the heat-exchange-amount control means includes:

a flow-control-valve-entrance-temperature estimation means for estimating, by the temperature measured by the third temperature-measuring means and the amount of heat exchanged in the coolant cooling means, flow-control-valve entrance temperature as coolant temperature at the entrance of the flow control valve;

a flow-control-valve-entrance-temperature control-range determination means for determining a control range of the flow-control-valve entrance temperature, so that a COP value is obtained, in which the difference between the value and the maximum value obtained when the flow-control-valve entrance temperature is varied under predetermined operational conditions is within a predetermined range; and

a control means for controlling the amount of heat exchanged in the coolant cooling means, so that the flow-control-valve entrance temperature estimated by the flow-control-valve-entrance-temperature estimation means is within the control range.

15. A refrigerator as recited in claim 2, further comprising:

a third temperature-measuring means for measuring coolant temperature at the exit of the radiator; wherein the heat-exchange-amount control means includes:

a flow-control-valve-entrance-temperature estimation means for estimating, by the temperature measured by the third temperature-measuring means and the

amount of heat exchanged in the coolant cooling means, temperature at the entrance of the flow control valve as coolant temperature at the entrance of the flow control valve;

a flow-control-valve-entrance-temperature control-range determination means for determining a control range of the flow-control-valve entrance temperature, so that a COP value is obtained, in which the difference between the value and the maximum value obtained when the flow-control-valve entrance temperature is varied under predetermined operational conditions is within a predetermined range; and

a control means for controlling the flow volume of the second coolant flowing in the coolant cooling means, so that the flow-control-valve entrance temperature estimated by the flow-control-valve-entrance-temperature estimation means is within the control range.

16. A refrigerator as recited in either claim 8 or claim 9, further comprising:

at least either a first pressure-measuring means for measuring pressure of the coolant between the exit of the flow control valve and the entrance of the evaporator, or a first temperature-measuring means for measuring temperature of the coolant at the exit of the flow control valve; wherein

the drying-ratio control-range determination means determines a control range of the drying ratio, using either the coolant pressure measured by the first pressure-measuring means or the coolant temperature measured by the first temperature-measuring means.

17. A refrigerator as recited in either claim 8 or claim 9, further comprising:

a second pressure-measuring means for measuring pressure of the coolant between the exit of the radiator and the entrance of the flow control valve; wherein

the drying-ratio control-range determination means determines a control range of the drying ratio, using the coolant pressure measured by the second pressure-measuring means.

18. A refrigerator as recited in any one of claims 14 to 17, further comprising:

at least one of the first pressure-measuring means for measuring pressure of the coolant between the exit of the flow control valve and the entrance of the evaporator, and the first temperature-measuring means for measuring temperature of the coolant at the exit of the flow control valve; wherein

the flow-control-valve-entrance-temperature control-range determination means determines a control range of the temperature at the entrance of the flow control valve, using either the coolant pressure measured by the first pressure-measuring means or the coolant temperature measured by the first temperature-measuring means.

19. A refrigerator as recited in any one of claims 14 to 17, further comprising:

a second pressure-measuring means for measuring pressure of the coolant between the exit of the radiator and the entrance of the flow control valve; wherein

the flow-control-valve-entrance-temperature control-range determination means determines a control range of the temperature at the entrance of the flow control valve, using the coolant pressure measured by the second pressure-measuring means.

20. An air conditioner having a compressor for compressing a coolant, a four-way valve for switching the direction in which the coolant as outputted from the compressor flows, an outdoor heat exchanger for exchanging heat between the coolant and outdoor air, a flow control valve for regulating the flow volume of the coolant, and an indoor heat exchanger for exchanging heat between the coolant and indoor air, characterized in that the air conditioner includes:

a coolant cooling/heating means for cooling as well as heating the coolant; and

a heat-exchange-amount control means for controlling the amount of heat exchanged in the coolant cooling/heating means; wherein

when the air conditioner is being operated for cooling, the coolant is circulated through the compressor, the outdoor heat exchanger, the coolant cooling/heating

means, the flow control valve, and the indoor heat exchanger, in that sequence, and

when the air conditioner is being operated for warming, the coolant is circulated through the compressor, the indoor heat exchanger, the flow control valve, the coolant cooling/heating means, and the outdoor heat exchanger, in that sequence.

21. An air conditioner as recited in claim 20, utilizing a nonflammable coolant whose global warming potential is lower than that of chlorofluorocarbon, wherein the coolant cooling/heating means includes:

a second compressor for compressing a second coolant whose energy consumption efficiency is higher than that of the coolant;

a second four-way valve for switching the direction in which the second coolant as outputted from the second compressor flows;

a first heat exchanger for exchanging heat between the second coolant and outdoor air;

a second flow control valve for regulating the flow volume of the second coolant; and

a second heat exchanger for exchanging heat between the coolant and the second coolant; wherein

when the air conditioner is being operated for cooling, the second coolant is circulated through the second compressor, the first heat exchanger, the second flow control valve, and the second heat exchanger, in that sequence, and

when the air conditioner is being operated for warming, the second coolant is circulated through the second compressor, the second heat exchanger, the second flow control valve, and the first heat exchanger, in that sequence.

22. An air conditioner as recited in claim 20, the compressor having an intermediary-pressure inlet for drawing in the coolant during compressing, the air conditioner further comprising:

a third flow control valve for regulating the flow volume of the coolant inputting into and outputting from the indoor heat exchanger;

a gas-liquid separator for separating into gas and liquid the coolant; and

a bypass pipe for introducing into the intermediary-pressure inlet part or all of the coolant gas separated by the gas-liquid separator; wherein

when the air conditioner is being operated for cooling, the coolant is circulated through the flow control valve, the gas-liquid separator, the third flow control valve, and the indoor heat exchanger, in that sequence, and

when the air conditioner is being operated for warming, the coolant is circulated through the indoor heat exchanger, the third flow control valve, the gas-liquid separator, and the flow control valve, in that sequence.

23. An air conditioner as recited in claim 20, further comprising:

a third compressor for compressing the coolant as compressed by the compressor;

a third flow control valve for regulating the flow volume of the coolant inputting into and outputting from the indoor heat exchanger;

a gas-liquid separator for separating into gas and liquid the coolant; and

a bypass pipe for introducing into the third compressor part or all of the coolant gas separated by the gas-liquid separator; wherein:

the coolant as outputted from the third compressor is inputted into the four-way valve, and

when the air conditioner is being operated for cooling, the coolant is flowed through the flow control valve, the gas-liquid separator, the third flow control valve, and the indoor heat exchanger, in that sequence, meanwhile, when the air conditioner is being operated for warming, the coolant is flowed through the indoor heat exchanger, the third flow control valve, the gas-liquid separator, and the flow control valve, in that sequence.

24. An air conditioner as recited in claim 20, further comprising:

a third radiator for radiating heat from the coolant as outputted from the compressor; and

a third compressor for compressing the coolant in a state in which heat of the coolant has been radiated away by the third radiator; and

a flow-route changing means for inputting into the third radiator the coolant as outputted from the compressor when the air conditioner is being operated for cooling, and for inputting into the third compressor when the air conditioner is being operated for warming.

25. An air conditioner as recited in claim 21, further comprising:

a third compressor for compressing the coolant as compressed by the compressor;

a third heat exchanger for exchanging heat between the coolant and the second coolant; and

a flow-route changing means for flowing the coolant as outputted from the compressor through the third heat exchanger and the third compressor, in that sequence, when the air conditioner is being operated for cooling, and into the third compressor when the air conditioner is being operated for warming; wherein

the coolant as outputted from the third compressor is inputted into the four-way valve, and the second coolant as outputted from the second heat exchanger is flowed through the third heat exchanger and the second compressor, in that sequence.

26. An air conditioner as recited in claim 21, further comprising:

a third compressor for compressing the coolant as compressed by the compressor;

a third heat exchanger for exchanging heat between the coolant and the second coolant; and

a forth flow control valve for regulating the flow volume of the second coolant flowing in the third heat exchanger; wherein

the coolant as outputted from the compressor is flowed through the third heat exchanger, the third compressor, and the four-way valve, in that sequence, and

part of the second coolant as outputted from the first heat exchanger is flowed

through the forth flow control valve, the third heat exchanger, and the second compressor, in that sequence.